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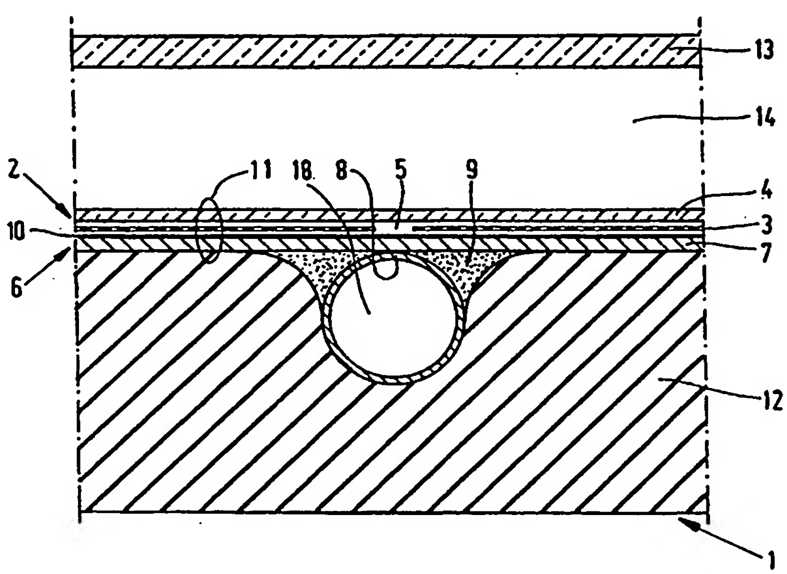

(57) Abstract

A panel–shaped hybrid photovoltaic/thermal device (1) comprising metal absorption means (6) for converting solar energy into thermal energy, and laminated, panel–shaped photovoltaic means (2) comprising photovoltaic cells (3) of a crystalline silicon for converting solar energy into electric energy. The photovoltaic means (2) and the absorption means (6) have been joined to form a single assembly with the interposition of a metal–containing plastic material (10) having bonding properties. The device (1) is constructionally simple and suited for optimizing the electric and thermal efficiency.

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A panel-shaped, hybrid photovoltaic/thermal device.

The invention relates to a panel-shaped, hybrid photovoltaic/thermal device comprising panel-shaped photovoltaic means for converting solar energy into electric energy, which photovoltaic means are mounted on panel-shaped absorption means for converting solar energy into thermal energy, which absorption means are provided with one or more flow channels for the purpose of delivering thermal energy during operation to a fluid flowing therein.

In practice, hybrid photovoltaic/thermal devices are generally used in combination with an electric subsystem for delivering electric energy generated by the photovoltaic means to an electric installation, and with a thermal subsystem for the storage of the thermal energy delivered by the absorption means. The thermal subsystem may, for example, comprise a boiler or the like for heating water.

In practice, hybrid photovoltaic/thermal devices are used both for household and for industrial purposes, and they are also referred to as hybrid solar collectors.

For use on a large scale, optimization both as regards the electric and thermal efficiency of a hybrid photovoltaic/thermal device and the cost of production are necessary. Furthermore, the device must operate reliably.

From the International patent publication WO 95/0273 a panel-shaped hybrid photovoltaic device is known comprising a structure which is relatively complicated and costly for production on a large scale. The absorption means and the photovoltaic means are mounted separately in a housing, whereby the interior of the housing must be void of air. This makes the known device less suitable for use in the open air, for example on a rooftop, because in that case the risk of the vacuum being broken as a result of damage to the housing is considerable.

Said vacuousness requirement has also its repercussions on the construction, which must be sufficiently strong mechanically in order to be able to withstand temperature gradients therein whilst maintaining the vacuum, in order to provide a reliable operation for a prolonged period of time.

In order to optimize the electric efficiency, an excellent heat conduction must be realised, both in a direction

perpendicularly to the panel, in this case the direction of incidence of solar energy, and laterally in the direction of the flow channels of the panel. After all, the efficiency of a photovoltaic cells decreases as the temperature increases.

From Patent Abstracts of Japan, publication no. 59015766, a panel-shaped hybrid photovoltaic device is known wherein the absorption means comprise a heat conduction construction of a high-molecular plastic. This construction is a compromise between the generated electric energy and the thermal energy on the one hand and the weight and the cost of the panel on the other hand, with the balance being in favour of the latter. Due to the relatively poor heat conduction capabilities of the plastic absorption means and the higher average working temperature that inevitably results therefrom, this construction does not exhibit an optimum electric efficiency. Since electric energy is valued more than thermal energy in practice, in view of its greater convertibility into other forms of energy, it is not possible with this known construction to provide an economically exploitable hybrid photovoltaic/thermal device as aimed at by the invention.

From US patent no. 4,700,013 a hybrid photovoltaic/-thermal device is known however, wherein lateral heat conduction does not play a role.

US patent no. 4,587,376 relates to a panel-shaped hybrid photovoltaic/thermal device which is particularly constructed for the use of photovoltaic cells of an amorphous silicon material. Also in this case it is not possible, due to the relatively low efficiency of said cells, to provide an exploitable system which is capable to a sufficient degree of meeting the electricity requirements of an average household. Without constructional alterations to the device it is not possible to substitute the cells of amorphous silicon for photovoltaic cells of monocrystalline and multicrystalline silicon, whose efficiency is typically twice as high as that of cells of amorphous silicon.

Accordingly, it is an object of the invention to provide a hybrid photovoltaic/thermal device which is of mechanically simple and reliable construction, which exhibits an optimized thermal and electric efficiency, adapted to the varying climatological conditions that occur at different geographic positions all around the globe, and which is as much as possible made of reliable, preferably generally commercially

available components.

The hybrid photovoltaic/thermal device according to the invention is characterized in that

- the photovoltaic means have a laminar structure, comprising at least two solar transmissive layers of an electrically insulating material, having there between electrically interconnected photovoltaic cells of the crystalline type, for example of silicon,

- the absorption means are made of a metal, and

- the laminated photovoltaic means and the absorption means have been provided as an integral unit with the interposition of a plastic material having bonding properties and heat transfer properties provided by a metal oxide and/or metal particles.

The invention has succeeded in providing a hybrid photovoltaic/thermal device which operates satisfactorily, that is, in terms of electric and thermal efficiency, which is reliable and which is economically sound as regards cost and exploitation, by combining components which are actually known per se.

The use of a laminar photovoltaic panel provides adequate protection against weather influences and thermal stresses, as well as the required electric insulation from the metal-containing interposed bonding plastic. The constructionally and thermally integrated device according to the invention exhibits a better lateral heat conduction than the known panels, a better protection against weather influences and an optimum electricity generating efficiency, due to the fact that the construction is suitable for the application of photovoltaic cells of monocrystalline and multicrystalline silicon material or similar types.

Plastics having thermal, elastic and bonding properties which are suitable for the purpose of the present invention are available in practice, for example a metal oxide-containing epoxy or a glue comprising metal particles dispersed therein for obtaining the desired thermal conduction properties. Suitable metals are, for example, so-called copper shavings. The glueing-together results in a robust construction whose economic life is sufficiently long for household use, without any further requirements being made as regards vacuousness and the like. The use of "deformable" plastic material furthermore offers the advantage of a wide range of options as regards the shape and the material of the absorption means and the photovoltaic means, whilst retaining the desired

thermal characteristics of the construction.

The plastic may thereby consist of an adhesive layer which extends either over the adjacent surfaces of the photovoltaic means and the absorption means, or only over selected positions, for example under the photovoltaic cells.

The laminar photovoltaic means as used in the invention preferably comprise two layers of a plastic material, between which the cells are disposed, whereby the layer by means of which the laminate is affixed to the absorption means, via the interposed layer of plastic material, typically has a thickness in the order of 0.5 mm or less. In order to obtain an optimum protection against weather influences, it is preferred in accordance with the invention to use a construction wherein the laminated photovoltaic cells are mounted on a solar transmissive carrier made of glass, which forms the outer layer onto which the sunlight incidences. The laminates may be manufactured separately at suitable production facilities, possibly tailored to the radiation conditions that prevail in the country where the device is to be used.

Although the photovoltaic means and the absorption means of the construction according to the invention may in principle have any desired shape, it has become apparent in practice that a flat or slightly curved panel-shaped construction is preferred for rooftop or wall mounting.

In the case of a panel-shaped construction, one or more flow channels may be provided by a space present between the absorption means and the fluid-tight panel-shaped means, for example a glass plate, which are spaced therefrom by some distance.

In yet another embodiment of the invention, the flow channels are provided by pipes or tubes or the like, which are in thermal contact with the absorption means. These pipes or tubes may be integral with the material of the absorption means, or be separately attached to an absorption plate, for example by welding or glueing.

The integral construction according to the invention furthermore makes it possible to use additional absorption means for the purpose of further increasing the electric and thermal efficiency without taking additional, complicated constructional measures.

In an embodiment of the invention, the above aspect has been realised in that further absorption means are spaced from the integrated photovoltaic means and the absorption means by some distance,

in such a manner that the absorption means in question are positioned opposite each other, with a space being formed therebetween.

Preferably, a thermally insulating, solar transmissive fluid, such as ambient air, is present in the space between the absorption means.

This measure makes it possible to achieve a reduction of the operating temperature of the photovoltaic means, and consequently a higher electric and thermal efficiency, because two thermally separated heat exchange sections are obtained, with the photovoltaic means being positioned in the so-called "cold" section. One and the same fluid can flow through the respective sections, starting with the cold section.

In yet another embodiment of the invention, a fluid-tight, solar transmissive panel, for example of glass, is disposed opposite the photovoltaic means, spaced from the integrated photovoltaic means and absorption means by some distance. The arrangement is thereby such that a space is formed between said panel and said photovoltaic means for containing therein a solar transmissive fluid, for example water, during operation.

Yet another enhancement of the electric efficiency is aimed at in an embodiment of the invention wherein the solar transmissive panel comprises means for concentrating sunlight in the direction of the photovoltaic means. These solar concentrating means may consist of adjacently disposed semicylindrical elements of a solar transmissive material, in such a manner that the concave sides of the elements are positioned opposite the photovoltaic means. These elements, together with the water, for example, that is present between the elements and the photovoltaic means, in particular concentrate diffuse sunlight, which is prevalent in a country such as the Netherlands, for example.

The integrated photovoltaic means and absorption means according to the invention make it readily possible to realise all embodiments in a box-shaped housing without any constructionally complicated supporting structures and the like being required. It should be kept in mind thereby that the high temperature gradients that may occur during use of a device make special demands on the construction, which demands become more exacting as the complexity of the construction increases.

In a preferred embodiment of the invention, invertor means, which are electrically connected with the laminar photovoltaic means, are integrated in the laminar photovoltaic means for the purpose of converting the generated direct current energy into alternating current energy and delivering it to the output terminals of the photovoltaic/-thermal device. Those skilled in the art will appreciate that this makes it possible to use a very simple, modular construction, wherein several hybrid photovoltaic/thermal devices according to the invention can be combined to form a single device of desired dimensions for converting solar energy.

By providing the invertor means with a so-called "maximum power point tracker", the total electric efficiency of a combination of hybrid photovoltaic/thermal devices according to the invention operating at different temperature levels simultaneously, can be higher than in the case of one invertor being used for the entire system.

Preferably, the invertor means are integrated in the laminate structure in such a manner that the thermal energy generated thereby during operation is delivered to the absorption means. This makes it possible to keep the operating temperature of the invertor means low, and the heat which is generated by the invertor means is added in a positive manner to the thermal energy being delivered by the absorption means.

The invention will be described in more detail hereafter by means of embodiments of hybrid photovoltaic/thermal devices as illustrated in drawings.

Figure 1 shows a schematic, sectional view of a part of a preferred embodiment of a hybrid photovoltaic/thermal device according to the invention.

Figure 2 shows a smaller-scale, schematic, perspective view of the device of Figure 1, which comprises an essentially rectangular housing.

Figure 3 shows a schematic, sectional view of a part of another embodiment of a hybrid photovoltaic/thermal device according to the invention.

Figure 4 shows a schematic, sectional view of a part of yet another embodiment of a hybrid photovoltaic/thermal device according

to the invention.

Figure 5 shows a schematic, sectional view of a part of yet another embodiment of a hybrid photovoltaic/thermal device according to the invention.

Figure 6 shows a schematic, sectional view of a part of yet another embodiment of a hybrid photovoltaic/thermal device according to the invention.

Figure 7 shows a schematic, perspective view of the device of Figure 6, which comprises an essentially rectangular housing.

Figure 8 shows a schematic, simplified plan view of amorphous photovoltaic means.

Figure 9 shows a schematic, sectional view of the photovoltaic means of Figure 8.

Figure 10 shows a schematic, simplified side view of crystalline photovoltaic means intended for use in the device according to the invention.

Figure 11 shows a schematic view of a possible electric connection of photovoltaic cells in the form of a laminate for use in the device according to the invention.

Figure 1 shows a schematic sectional view, not to a large scale, of a part of a panel-shaped hybrid photovoltaic/thermal device according to a preferred embodiment of the invention, which is indicated as a whole by numeral 1.

The device comprises a photovoltaic laminate 2 consisting of photovoltaic cells 3 of a crystalline silicon material, which are mounted on a panel-shaped, solar transmissive carrier 4, for example in the form of a glass plate. The photovoltaic cells 3 are affixed to the carrier with interspaces between them by means of a solar transmissive foil or envelope 5 made up of two electrically insulating layers of plastic material, for example hot adhesive material. The layers have a thickness typically in the order of 0.5 mm or less, at least as regards the layer with which the laminate 2 adjoins absorption plate 7.

The device 1 furthermore includes absorption means 6 shaped as a metal absorption plate 7, with tubes or pipes 8, which are in thermal contact with the absorption plate 7, being present on one side of the absorption plate 7. The figure shows only one tube or pipe 8. Those skilled in the art will appreciate, however, that several tubes or pipes

8 may be attached to the absorption plate 7, for example by means of a soldered connection or a weld 9.

In accordance with the invention, the photovoltaic means 2 and the absorption means 6 are joined to form an integral unit by means of an interposed bonding and heat conducting layer of plastic material 10. Said layer 10 may extend over the entire area of the photovoltaic cells 3 or over a part thereof, for example only in the free areas between the photovoltaic cells 3. It has become apparent that a synthetic glue of a metal oxide-containing epoxy is very suitable for use in the invention.

The layer 10 may also consist of a glue which contains metal particles dispersed therein so as to improve its heat transfer properties. The use of this "deformable" plastic, which provides a good connection between the photovoltaic means 2 and the absorption means 6, results in excellent heat transfer characteristics of the assembly 11.

The photovoltaic means 2 and the absorption means 6 which have been joined to form a single assembly 11 in this manner, are supported with tubes or pipes 8 on an insulating layer 12, for example a layer of glass wool, polyurethane foam and the like.

In most practical applications, a solar transmissive cover plate 13, for example a glass plate, is disposed opposite and spaced from the photovoltaic means 2. A thermally insulating, solar transmissive fluid, for example ambient air, is present in the space 14 between the cover plate 13 and the carrier 4.

Figure 2 is a perspective view of the device 1 according to Figure 1 disposed in an approximately rectangular housing 15, wherein the device comprises an inlet 16 and an outlet 17 for fluid 18, such as water, which flows through tubes or pipes 8 during use. The figure furthermore schematically shows electric terminals 19 for delivering electric energy generated by the photovoltaic means.

Those skilled in the art will appreciate, that device 1 is characterized by a very simple, robust and reliable construction. The photovoltaic means 2 and the absorption means 6 can each be optimally constructed in advance, tailored to specific requirements, after which they can be glued together to form a single unit 11 in accordance with the invention. In this manner, it is possible to provide a constructionally simple, optimized and economically advantageous hybrid photovoltaic/thermal device according to the invention. The operation of the device 1 is

essentially as follows.

Sunlight or solar rays incident on the cover plate 13 reach the photovoltaic cells 3 via the carrier 4, which photovoltaic cells 3 convert the energy of the incident sunlight into electric energy. The exact operation of the photovoltaic cells is not relevant for a correct understanding of the present invention. An explanation of the operation of photovoltaic cells can be found in the book "Solar Cells" by M. Green.

Thermal radiation from the photovoltaic means 2 is blocked by the glass plate 13, because it is opaque to infrared radiation. Also convection losses to the outside ambient air are suppressed by the glass plate 13. The glass plate 13 transmits as much sunlight as possible, of course, which sunlight is absorbed by the photovoltaic panel 2 and absorption plate 7 and delivered in the form of thermal energy to fluid 18, for example water, which flows through the tubes or pipes 8.

The electric energy generated by the photovoltaic means 2 is available on terminals 19. The water in the tubes or pipes 8, which is heated via the absorption plate 7, circulates via the inlet 16 and the outlet 17 in a forced or in a natural manner during operation, and it generally passes through a heat storage vessel or container, for example a boiler (not shown) which is known per se. The stored heat may be used for heating bath and shower water, for example, or for heating purposes, for example via a central heating system. Also other applications are conceivable, of course.

Figure 3 is a sectional view, not to scale, of another embodiment of a hybrid photovoltaic/thermal device according to the invention, which is indicated as a whole by reference numeral 20. In this figure, like elements or elements performing the same function as in the embodiment according to Figure 1 are indicated by the same reference numerals, and they will not be explained further.

A fluid-tight layer or plate 21 is disposed on the insulating layer 12 instead of the tubes or pipes 8 of the first embodiment according to Figure 1, and the photovoltaic means 2 and the absorption means 6 according to the invention, which form a single unit 7, are spaced therefrom by some distance. Between the plate 21 and the absorption plate 7 is a space 22, which makes up a flow channel for a fluid such as water, to which the absorption means 6 deliver their heat during use. Although this is not shown in the figure, it will be apparent that space 21 is

provided with inlet and outlet means for said fluid. See Figure 2. Furthermore, stiffening elements (not shown), for example in the form of partitions, may be disposed in the space 21 in the direction of flow of the fluid.

Also in this case it applies that it is possible to build up a relatively simple device with the integrated photovoltaic means 2 and the absorption means 6 according to the invention, without using complicated mechanical constructions. This is possible because the assembly 11, or its component parts, and plate 21, insulating layer 12 and cover plate 13 can be mounted in the walls of a housing 15 in a simple manner. See Figure 2. The plate 21 is preferably made of a material which is sufficiently strong for the purpose of the invention.

Figure 4 shows yet another embodiment, not to scale, of the hybrid photovoltaic/thermal device according to the invention, which is indicated as a whole by reference numeral 25. Also in this case it applies that like elements or elements which perform a similar function as described above are indicated by the same reference numerals.

This embodiment is based on the embodiment of Figure 3, wherein a fluid-tight, solar transmissive panel 23 is furthermore disposed parallel to the carrier, spaced therefrom by some distance, in such a manner that a space 24 is formed between the panel 23 and the carrier 4.

The spaces 22 and 24 now form two flow channels, whereby a fluid, for example water, can flow through both channels jointly or through each channel separately. As regards space 24 it applies that the fluid must be a solar transmissive fluid.

Arrows 26 indicate a possible direction of flow of fluid in the two spaces 22 and 24, whereby cold water, for example, enters space 24 and exits space 25 as hot water, also in this case via suitable inlet and outlet means (see Figure 2), of course.

Those skilled in the art will appreciate that a fluid-tight, solar transmissive panel 23 as illustrated in Figure 4 can also be used with the device of Figure 1. In the illustrated embodiment, the photovoltaic cells 3 are by way of example disposed between two carriers 4, that is, in the form of a sandwich structure.

Yet another embodiment of a hybrid photovoltaic/thermal device according to the invention, which is indicated as a whole by

reference numeral 30, is shown, not to scale, in Figure 5. Again it applies that like elements or elements having like functions as described above are indicated by the same reference numerals.

In this embodiment, two separate absorption sections are provided. A first section comprising the photovoltaic means 2, the absorption means 6 and the plastic material 10 joined to form a single assembly 11, and a second section comprising a flow channel 22, which is made up of a fluid-tight layer or plate 21 provided on the insulating layer 12, with absorption means in the form of a further absorption plate 27 being spaced therefrom. As is shown in Figure 5, the assembly 11 is present between the cover plate 13 and a further absorption plate 27, in such a manner that a solar transmissive, thermally insulating space 28 is formed between the two absorption sections, which space is filled with a solar transmissive, thermally insulating fluid, such as air.

In this embodiment, the photovoltaic cells 3 are mounted on the carrier 4 with interspaces which are dimensioned such that sufficient sunlight can find its way from the cover plate 13, via the assembly 11, to the further absorption plate 27. To this end, plastic material 10 extends substantially under the photovoltaic cells 3, whilst also absorption plate 29 of the absorption means 6 transmits sunlight in the interspaces between the photovoltaic cells 3. A perforated absorption plate 29 or the like may be used for this purpose. In the case of a transparent plastic material 10, said plastic material may extend over the entire area between the photovoltaic means 2 and the perforated absorption plate 29, of course.

Space 28 provides thermal insulation between the photovoltaic means 2 of the assembly 11 and the second absorption section made up of flow channel 22.

When a fluid 18 flows through tubes or pipes 8, the photovoltaic cells 3 can be cooled separately, which has a positive effect on the electric efficiency. The thermal conversion mainly takes place in the second absorption section comprising the further absorption plate 27. Fluid 18 may first flow through tubes or pipes 8 and subsequently through the flow channel 22, if desired. That is, fluid 18 flows through the absorption means 6 of the assembly 11 in cold condition.

Those skilled in the art will appreciate, that in this embodiment a flow channel 24 may be formed above the assembly 11 as well,

as is shown in Figure 4. Furthermore, the second absorption section may be realized via an absorption plate fitted with tubes or pipes, as has been described with reference to Figure 1.

It is also possible to use a combination of a bonding plastic material 10 and mechanical clamping means 31, of course. Mechanical clamping means 31 which are suitable for the purpose of the invention are known per se in practice, and they do not require any further explanation to those skilled in the art.

The advantage of this embodiment, which may also be indicated by the term "double absorption", is that the operating temperature of the photovoltaic means 2 can be lower than is the case in the embodiments according to Figures 1, 3 and 4, because generated heat is delivered to the fluid 18. In practice this means that this enables a higher electric efficiency of the photovoltaic means than in the above-described embodiments.

Figure 6 is a sectional view, not to scale, of yet another embodiment of the invention, which is indicated as a whole by reference numeral 35.

Beneath the cover plate 13 are means 32 for concentrating incident solar light on the cover plate 13 in the direction of the photovoltaic cells 3.

In the illustrated embodiment, means 32 consist of interconnected semicylindrical elements 33 of a solar transmissive material, whose concave sides are disposed opposite the photovoltaic cells 3. The photovoltaic cells 3 are dimensioned such that they extend, with spaces between them, in the longitudinal direction of and substantially under the elements 33, all this as schematically illustrated in Figure 7.

The cover plate 13 and the means 33 may be separate components, but they may also form a single unit. A thermally insulating transparent fluid, for example ambient air, is present in the spaces 34 between the convex sides of the means 33 and the cover plate 13. Although Figure 5 shows the embodiment of the absorption means 6 comprising tubes or pipes 8, it will be appreciated that a construction comprising a flow channel 22 as shown in Figure 3 is also possible in this embodiment. Also in this case no significant constructional efforts are required.

The absorption means 6 to be used in the invention preferably consist of a metal, such as steel plate, which may be provided with an additional heat-absorbing coating, for example a heat-absorbing paint.

The photovoltaic means 2 comprise photo-converters which are suitable for converting solar energy or sunlight into electric energy, which photo-converters, also called solar cells, are of monocrystalline or multicrystalline silicon, or comparable types. Suitable cells are, for example, the 100 x 100 mm^2 or 125 x 125 mm^2 n-type on p-type multicrystalline silicon solar cells which are marketed by Shell Solar Energy B.V.

Figure 8 shows the typical structure of an amorphous silicon cell 41, a cross-sectional view of which is shown in Figure 9.

The cell 41 comprises a stack made up of a solar transmissive upper layer 36, generally glass, a transparent upper electric contact 37, amorphous silicon 38, a lower electric contact 39 and a carrier 40.

As is shown in Figures 8 and 9, the amorphous silicon cell comprises a thin structure which is built up of strips.

Figure 10 is a sectional view of a simplified structure of a crystalline photovoltaic cell 42, which consists of a stack which is made up of a first n-type silicon layer 43, a second p-type silicon layer 44, a p-n transition 45 formed between the two layers, electric contacts 46 provided on the layer 43, and an electric contact 47 provided on the layer 44.

Generally, the electric efficiency of the cells of crystalline silicon is twice as high as that of cells of amorphous silicon (14% against 7%, respectively). For the purpose of the invention, the crystalline cells are advantageous. However, it is noted that the use of cells of amorphous silicon is possible with the double-channel embodiments as shown in Figures 4 and 5.

Figure 11 shows a possible electric connection of photovoltaic cells 42 to form photovoltaic means 2 for use in the invention. The cells 42 are connected in series via electric conductors 50, thus providing electric terminals 48 and 49.

In a preferred embodiment of the invention, the terminals 48, 49 are connected to invertor means 51, which comprise

terminals 52, 53. The invertor means 51 convert the direct current energy that is generated by the cells 42 into alternating current energy. Invertor means which are suitable for this purpose are known per se in practice, and they do not require any further explanation.

It is preferred to use invertor means 51 which are provided with a so-called "maximum power point tracker", by means of which the total electric energy delivered by electrically interconnected photovoltaic means 2, which operate at different temperatures, is higher than that of photovoltaic means 2 which are interconnected without the use of such a "maximum power point tracker". A description of such a maximum power point tracker can be found in the literature on electronic power conversion, so that it need not be explained in more detail herein.

The invertor means 51 are preferably integrated with photovoltaic means 2 to form a laminate, whereby the heat generated by the invertor means 51 is preferably delivered to the absorption means 6, which has a positive effect on the thermal efficiency of the device.

For practical use, for example for household applications, a plurality of hybrid photovoltaic/thermal devices or modules can be combined in one common housing 15 to form a single convertor device or solar collector.

Although the invention has been described in the above by means of a number of embodiments, it will be appreciated by those skilled in the art that the novel and inventive concept is not limited to said embodiments.

CLAIMS

1. A panel-shaped, hybrid photovoltaic/thermal device comprising panel-shaped photovoltaic means for converting solar energy into electric energy, which photovoltaic means are mounted on panel-shaped absorption means for converting solar energy into thermal energy, which absorption means are provided with one or more flow channels for the purpose of delivering thermal energy during operation to a fluid flowing therein, characterized in that

- the photovoltaic means have a laminar structure, comprising at least two solar transmissive layers of an electrically insulating material, having therebetween electrically interconnected photovoltaic cells of the crystalline type, for example of silicon,
- the absorption means are made of a metal, and
- the laminated photovoltaic means and the absorption means have been provided as an integral unit with the interposition of a plastic material having bonding properties and heat transfer properties provided by a metal oxide and/or metal particles.

2. A hybrid photovoltaic/thermal device according to claim 1, wherein said interposed plastic is a metal oxide-containing epoxy.

3. A hybrid photovoltaic/thermal device according to any of the preceding claims, wherein said photovoltaic means are disposed between two solar transmissive layers of plastic material, wherein the layer facing said absorption means typically comprises a thickness in the order of 0.5 mm.

4. A hybrid photovoltaic/thermal device according to any of the preceding claims, wherein the laminated photovoltaic means are mounted on a solar transmissive, panel-shaped carrier, for example a carrier made of glass.

5. A hybrid photovoltaic/thermal device according to any of the preceding claims, wherein a flow channel is made up of a space between said absorption means and fluid-tight panel-shaped means being spaced therefrom by some distance.

6. A hybrid photovoltaic/thermal device according to claim 5, wherein said flow channels are made up of pipes, tubes and the like, which are in thermal contact with said absorption means.

7. A hybrid photovoltaic/thermal device according to any of the preceding claims, wherein further absorption means are spaced from the integral photovoltaic means and absorption means by some distance, in such a manner that said absorption means are positioned opposite each other, wherein the integral photovoltaic means and the absorption means are solar transmissive.

8. A hybrid photovoltaic/thermal device according to any of the preceding claims, wherein a fluid-tight, solar transmissive panel, for example glass, is disposed opposite the photovoltaic means, spaced from the integrated photovoltaic means and absorption means by some distance, in such a manner that a space is formed between said panel and said photovoltaic means for containing a solar transmissive fluid, for example water, therein during operation.

9. A hybrid photovoltaic/thermal device according to claim 8, wherein the solar transmissive panel in question comprises means for concentrating sunlight in the direction of the photovoltaic means.

10. A hybrid photovoltaic/thermal device according to claim 9, wherein said sunlight-concentrating means consist of adjacently disposed semicylindrical elements of a solar transmissive material, in such a manner that the concave sides of said elements are positioned opposite said photovoltaic means.

11. A hybrid photovoltaic/thermal device according to claim 10, wherein said solar transmissive, fluid-tight panel and said solar transmissive elements are joined to form a single unit.

12. A hybrid photovoltaic/thermal device according to claim 11, wherein a thermally insulating fluid, for example ambient air, is present in the spaces between the panel and the convex sides of said elements.

13. A hybrid photovoltaic/thermal device according to any of the preceding claims, wherein invertor means, which are electrically connected to said laminar photovoltaic means, are integrated in said laminar photovoltaic means for the purpose of converting generated direct current energy into alternating current energy and delivering it to output terminals of the photovoltaic/thermal device.

14. A hybrid photovoltaic/thermal device according to claim 13, wherein said invertor means comprise a so-called "maximum power point tracker".

15. A hybrid photovoltaic/thermal device according to claim 13 or 14, wherein said invertor means are arranged in such a manner that the thermal energy generate thereby during operation is delivered to said absorption means.

16. A hybrid photovoltaic/thermal device according to any of the preceding claims, comprising an essentially box-shaped housing, at least one side of which is made of a solar transmissive material.

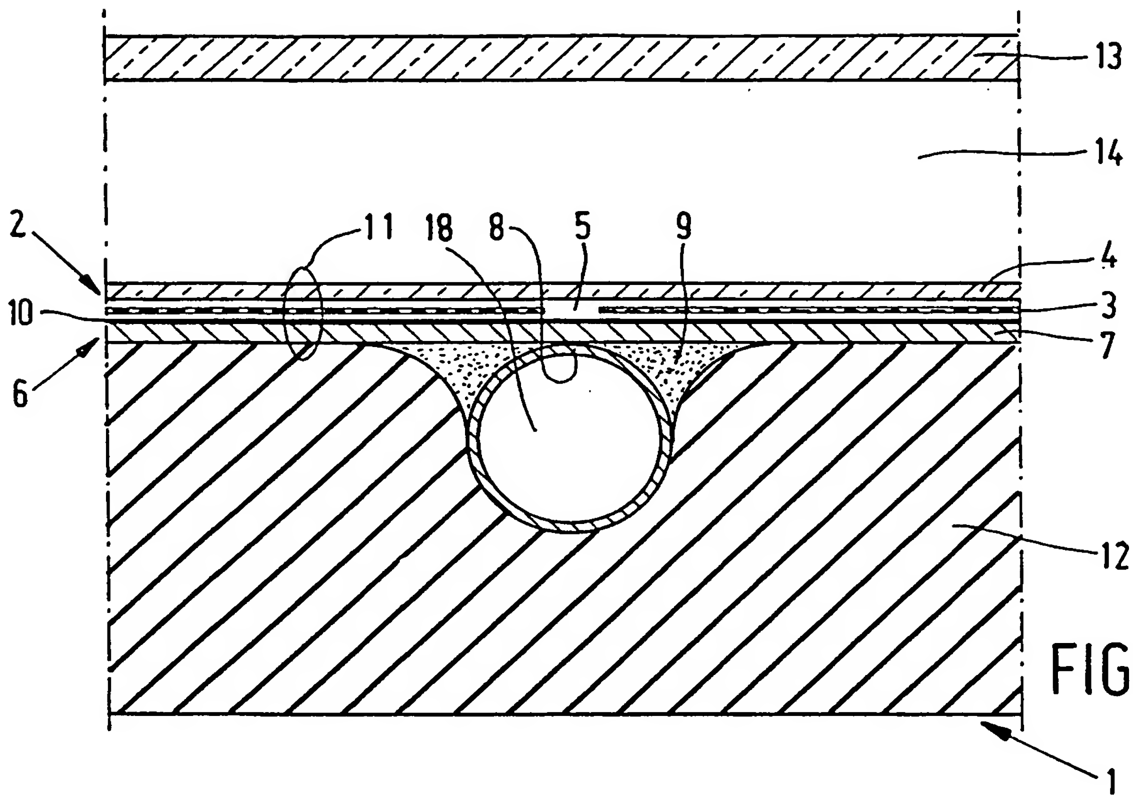

FIG.1

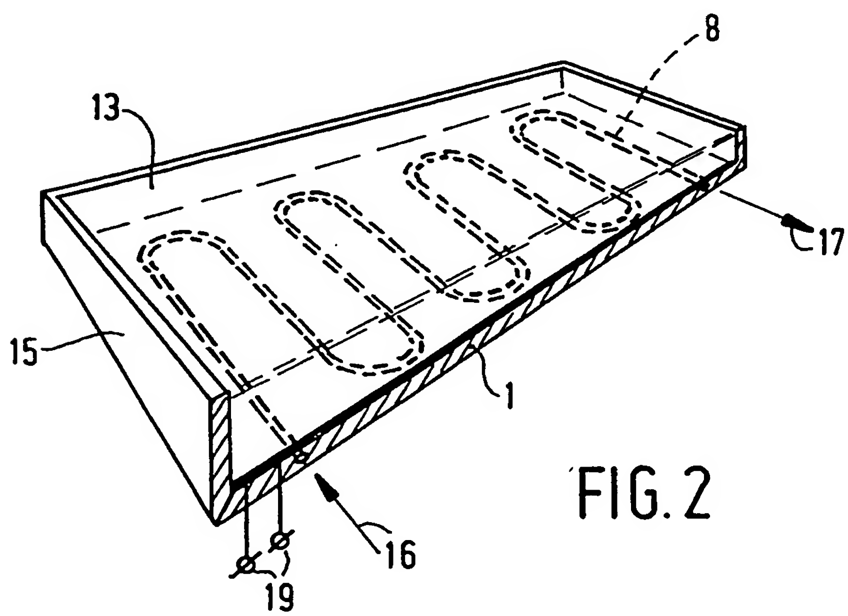

FIG. 2

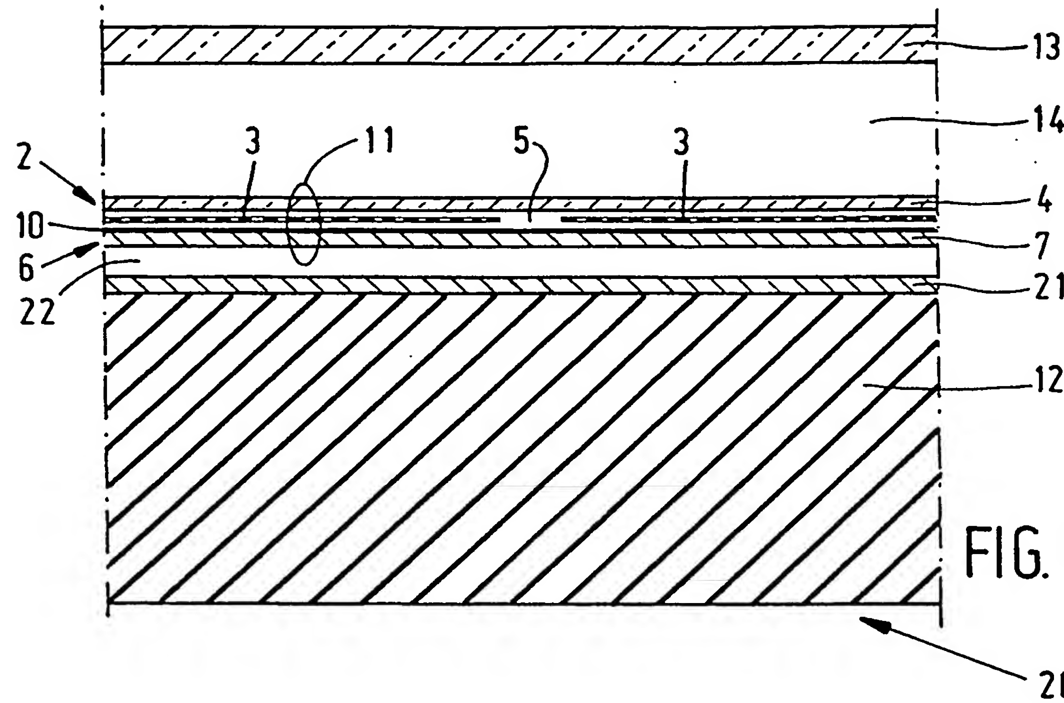
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FIG. 3

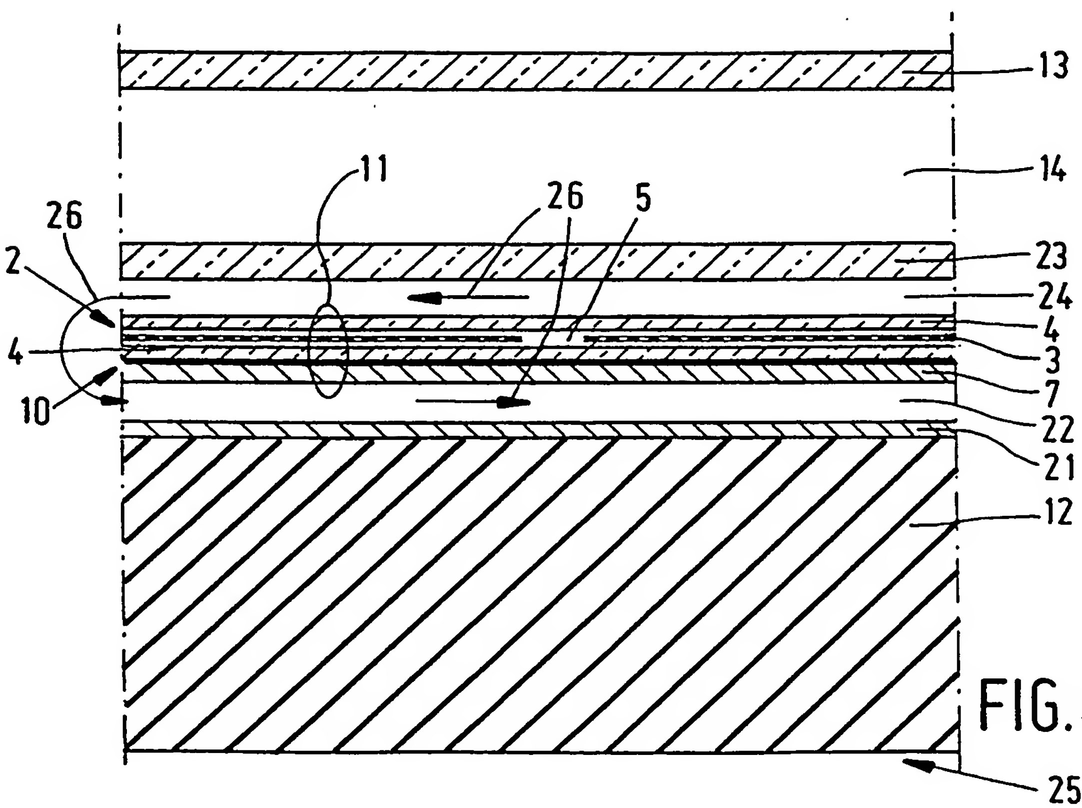
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FIG. 4

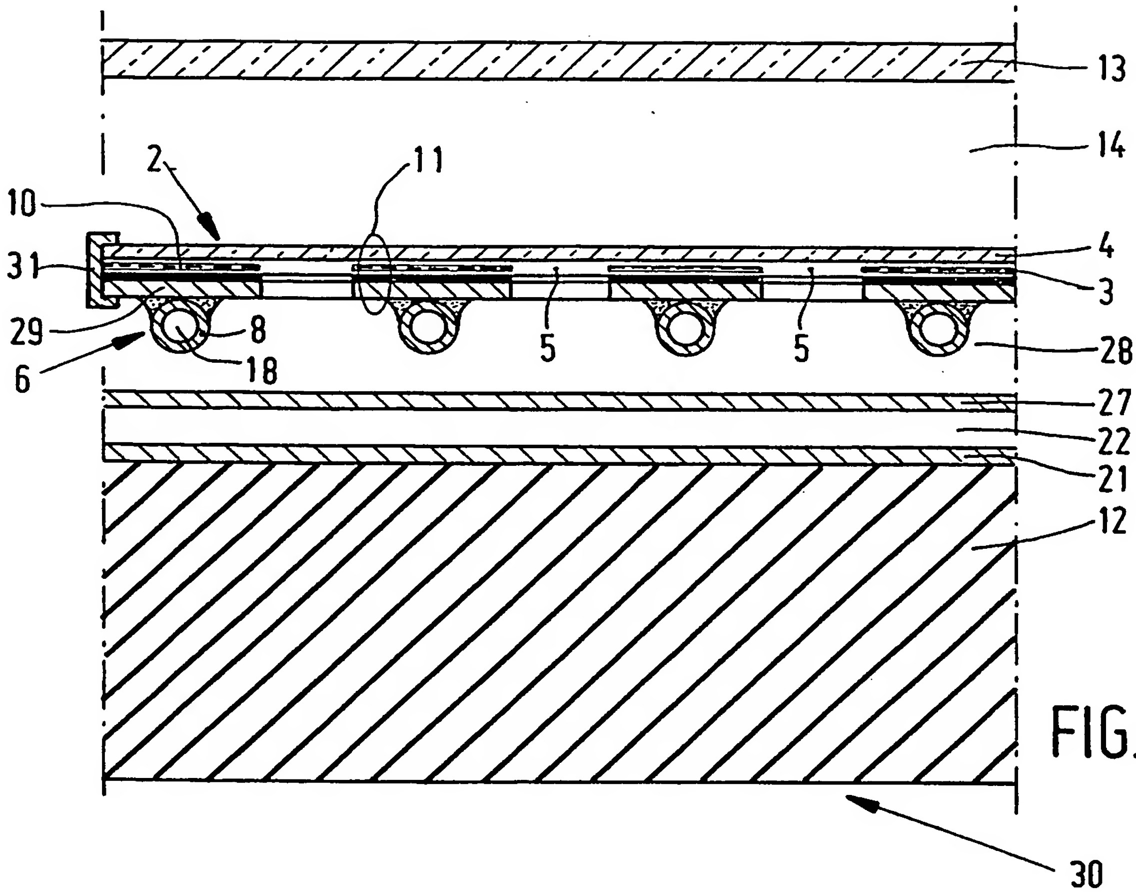

FIG. 5

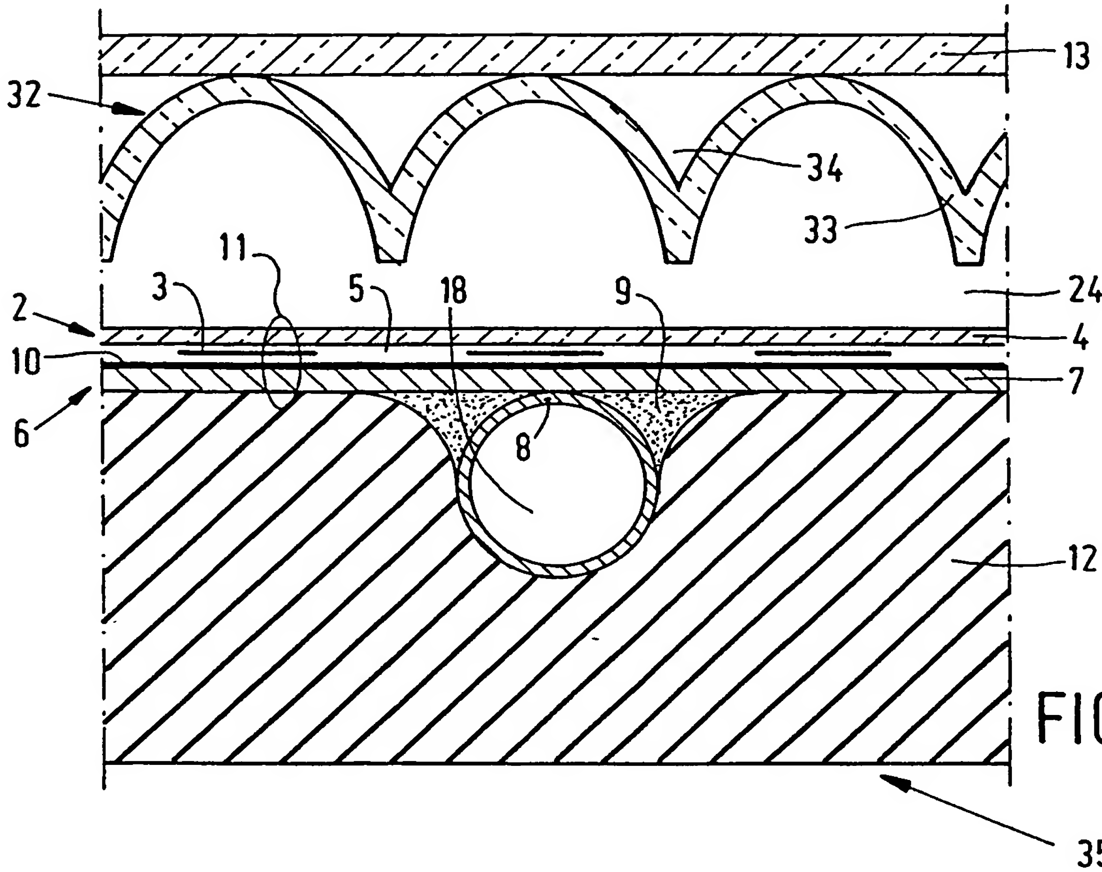

FIG.6

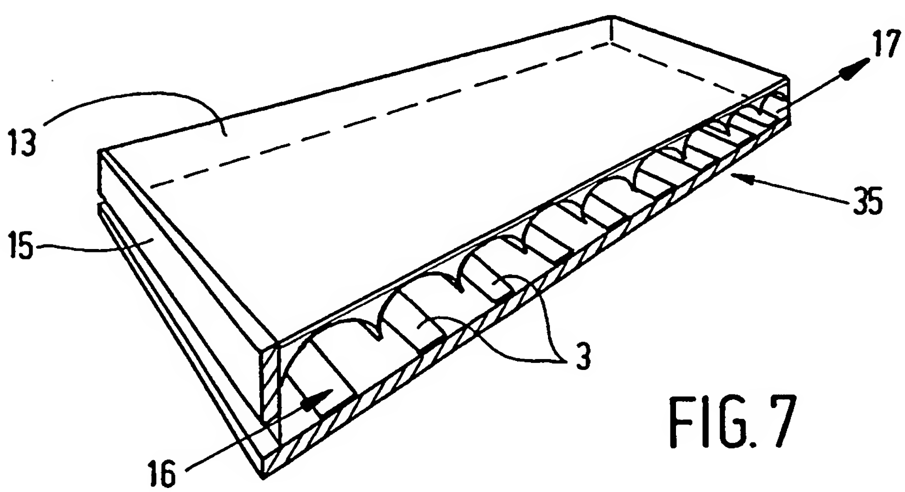

FIG.7

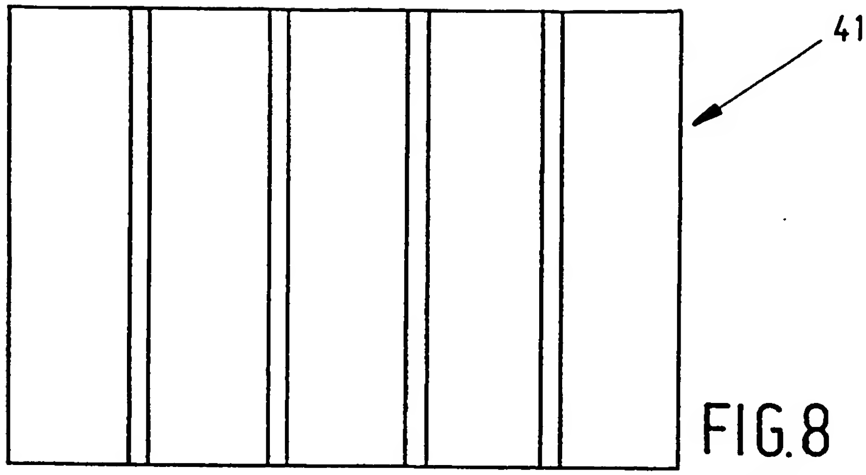

FIG.8

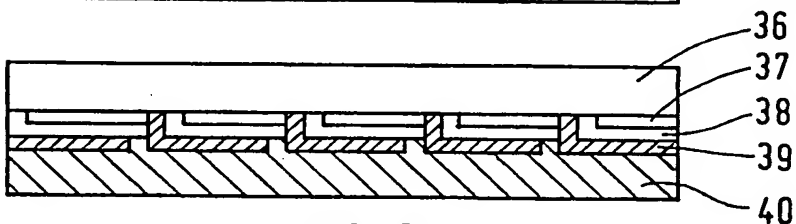

FIG.9

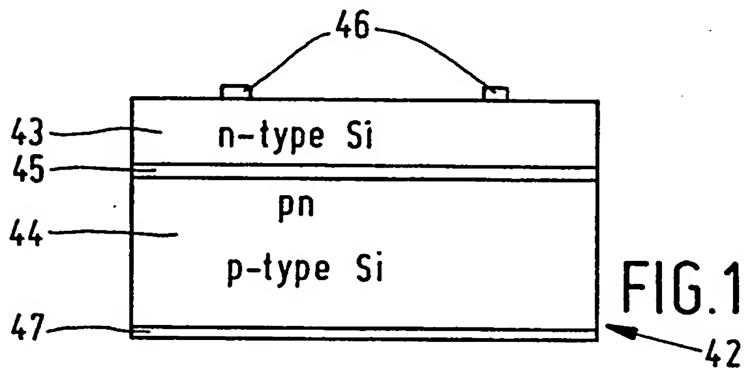

FIG.10

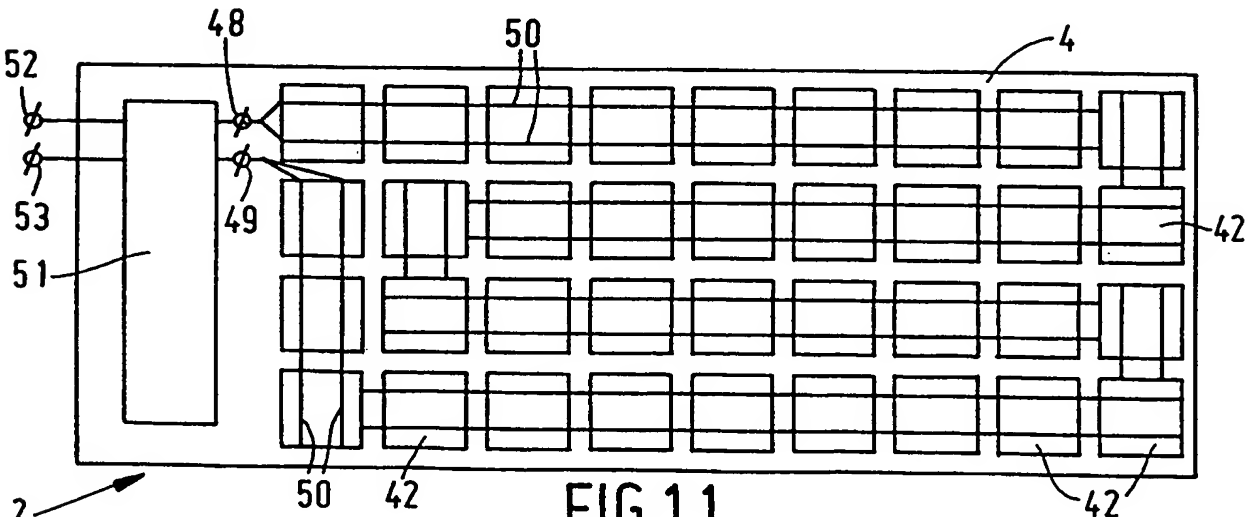

FIG.11

INTERNATIONAL SEARCH REPORT

Intern[illegible]al Application No
PCT/NL [illegible]00477

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01L31/058 F24J2/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01L F24J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 700 013 A (SOULE DAVID E) 13 October 1987 cited in the application see column 1, line 63 - column 2, line 30; figure 1 ---	1,9,10
A	DE 38 31 631 A (TELEFUNKEN SYSTEMTECHNIK) 29 March 1990 cited in the application see the whole document ---	1,16
A	PATENT ABSTRACTS OF JAPAN vol. 008, no. 104 (M-296), 16 May 1984 & JP 59 015766 A (TOKYO SHIBAURA DENKI KK), 26 January 1984 cited in the application see abstract ---	1,6,16

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 September 1998	12/10/1998

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL [illegible]0477

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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A	US 5 572 070 A (R. J. ROSS) 5 November 1996 see the whole document ---	1
A	EP 0 789 405 A (TOYOTA JIDOSHA K K) 13 August 1997 see claims 1-11; figures 1,4,6 ---	1,8-10
A	HAAN DE S W H ET AL: "DEVELOPMENT OF A 100W RESONANT INVERTER FOR AC-MODULES" COMMISSION OF THE EUROPEAN COMMUNITIES. E.C. PHOTOVOLTAIC SOLAR ENERGY CONFERENCE. PROCEEDINGS OF THE INTERNATIONAL CONFERENCE, vol. 1, 11 April 1994, pages 395-398, XP002033672 see the whole document ---	1,13,14
A	Y. NAKATA ET AL.: "A 30kWP concentrating photovoltaic/thermal hybrid system application" 16TH IEEE PHOTOVOLTAIC SPECIALISTS CONFERENCE, 27 - 30 September 1982, pages 993-998, XP002063329 SAN DIEGO, USA -----	

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